# Climate Change, Human-Caused or Natural?

*By John Benson*

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## 1. Introduction

When I decided to use the above title, I was pretty sure a majority of the U.S. public would select the first option (human-caused). But after selecting it, did a search for a recent poll from a respected pollster that asked this question.

I found a Pew Research poll that asked "How much do Americans think humans contribute to climate change?"[1] The answers to this question were:

A great deal..... 45%

Some ..... 29%

Not too much or not at all ..... 25%

So, 74% believe that humans contribute to climate change a great deal or some.

Then I looked for a paper by a reputable source, that explored this issue a bit more deeply, as well as citing evidence for this the viewpoints. I found the paper, which is referenced in section 2. This paper cited both pro and con evidence, but given the strong pro evidence, I made the following decision.

The primary reference is Reference 2 (bottom of this page)' The last section in Ref. 2 is: "Pros and Cons at a Glance" although it argues both sides in the rest of Ref. 2. Your author has researched the scientific evidence, and I believe that climate change is anthropogenic (human-caused), thus I will skip the "Cons in this paper." If some readers want to see the con-arguments, go through the reference 2 link, start with "Pros and Cons at a Glance," the following subsections are a summary of pros & cons, the full text of the pro arguments, and then the full text of the con arguments.

I have also done something else unusual for my papers. Since this is a very important issue, I included all of the secondary references (over 200). Note that secondary references are at the end of this document. Primary references (only 8) are, like the ones below, at the end of each page. This paper is over 5,000 words (w/o the secondary references, over 9,000 words with these), which is longer than my normal paper, but this is a very important read.

## 2. Human Responsibility for Climate Change?

*Average surface temperatures on earth have risen more than 2°F (1.11°C) over the past 100 years.[205] During this time period, atmospheric levels of greenhouse gases such as carbon dioxide ($CO_2$) and methane ($CH_4$) have notably increased.[10, 11] This site explores the debate on whether climate change is caused by humans (also known as anthropogenic climate change).[2]*

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[1] Brian Kennedy and Alec Tyson, Pew Research Center, "How Americans View Climate Change and Policies to Address the Issue," Dec 9, 2024, https://www.pewresearch.org/science/2024/12/09/how-americans-view-climate-change-and-policies-to-address-the-issue/

[2] Written and fact-checked by the Editors of ProCon, Britannica, Climate Change - Is Human Activity Primarily Responsible for Global Climate Change? Last Updated: Feb 15, 2025, https://www.britannica.com/procon/climate-change-debate#ref398265

*The pro side argues rising levels of atmospheric greenhouse gases are a direct result of human activities such as burning fossil fuels, and that these increases are causing significant and increasingly severe climate changes including global warming, loss of sea ice, sea level rise, stronger storms, and more droughts with attendant wildfires. They contend that immediate international action to reduce greenhouse gas emissions is necessary to prevent dire climate changes.*

*The con side argues human-generated greenhouse gas emissions are too small to substantially change the earth's climate and that the planet is capable of absorbing those increases. They contend that warming over the 20th century resulted primarily from natural processes such as fluctuations in the sun's heat and ocean currents. They say the theory of human-caused global climate change is based on questionable measurements, faulty climate models, and misleading science.*

## 2.1. Early Science on Greenhouse Gasses & Climate Change

*Scientists have known of the heating potential (greenhouse effect) of gases such as $CO_2$ since at least 1859, when Irish physicist John Tyndall first began experiments leading to the discovery that $CO_2$ in the atmosphere absorbs the sun's heat.[126]*

*On Feb. 16, 1938, engineer Guy S. Callendar published an influential study suggesting increased atmospheric $CO_2$ from fossil fuel combustion was causing global warming.[127] Many scientists at that time were skeptical of Callendar's conclusion, arguing that that natural fluctuations and atmospheric circulation changes determined the climate, not $CO_2$ emissions.[158]*

*In Mar. 1958, U.S. climate scientist Charles Keeling began measuring atmospheric $CO_2$ at the Mauna Loa observatory in Hawaii for use in climate modeling.[128] Using these measurements, Keeling became the first scientist to confirm that atmospheric $CO_2$ levels were rising rather than being fully absorbed by forests and oceans (carbon sinks).[129] When Keeling began his measurements, atmospheric $CO_2$ levels stood at 315 parts per million (ppm).[10]* In January 2025 the atmospheric $CO_2$ levels were 426.65 ppm,[3] and these were also measured at the Mauna Loa observatory, and the carbon dioxide data on Mauna Loa constitute the longest record of direct measurements of $CO_2$ in the atmosphere.

*The U.S. National Academy of Sciences issued a 1977 report titled "Energy and Climate" that concluded the burning of fossil fuels was increasing atmospheric $CO_2$, and that increased $CO_2$ was associated with a rise in global temperatures.[130]*

*On June 23, 1988 National Aeronautics and Space Administration (NASA) scientist James Hansen presented testimony to the US Senate stating that increases in $CO_2$ were warming the planet and "changing our climate."[131, 132] At the time, MIT meteorologist Richard Lindzen criticized these findings, arguing that computerized climate models were unreliable and that natural processes would balance out any warming caused by increased $CO_2$.[133]*

[3] https://gml.noaa.gov/ccgg/trends/

## 2.2. IPCC & UN Framework Convention on Climate Change

*The Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to review research on global climate change (as of Mar. 2020, there were 195 IPCC member countries).[136] The IPCC issued its first assessment report in 1990 stating that "emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases," resulting in "an additional warming of the Earth's surface."[135]*

*The United Nations Framework Convention on Climate Change (UNFCCC) was signed by U.S. President George H.W. Bush on Oct. 13, 1992.[137] The goal of the convention was the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[138] The UNFCCC became the parent treaty for the 1997 Kyoto Protocol and the 2015 Paris Agreement.[159]*

## 2.3. Kyoto Protocol, Paris Agreement, & Other Info

*Over 161 nations met in Kyoto, Japan, in Dec. 1997 to negotiate a treaty to limit greenhouse gas emissions and work toward the objectives of the UNFCCC. The resulting Kyoto Protocol,[139] signed by President Bill Clinton, set binding targets for 37 industrialized countries and the European Union to reduce greenhouse gas emissions roughly 5% below 1990 levels by 2012.[140]*

*President George W. Bush withdrew the United States from the Kyoto Protocol in March 2001 due to Senate opposition and concerns that limiting greenhouse gas emissions would harm the US economy. From July 16-27, 2001 the COP 6 conference took place in Bonn, Germany, and the final amendments to the Kyoto Protocol were made.* COP is "Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC)*. 179 countries reached a binding agreement without US participation.[141]*

*On Mar. 2, 2008 the Heartland Institute sought to challenge the idea that human activity was causing climate change by holding its own international conference on climate change. At the conference, 98 speakers including PhD climate scientists from major universities argued that global warming was most likely a natural event.[148]*

*In Dec. 2009 the COP 15 conference took place in Copenhagen, Denmark. The resulting Copenhagen Accord, signed by 114 nations including the United States and China, called for "deep cuts" in human greenhouse gas emissions in order to make sure that earth's temperature rises no more than 1.5°C above pre-industrial levels.[142]*

*In Dec. 2015, the COP 21 met in Paris where 195 countries, including the United States, adopted the Paris Agreement.[176, 178] The agreement's central aim was to prevent global temperatures from rising more than 1.5°C – 2°C above pre-industrial levels. Under the agreement, all countries were required to create a national plan to reduce greenhouse gas emissions and report regularly on their individual progress towards meeting their emission reduction goals.[177] President Obama, still in office at the time, called the agreement a "turning point for the world" that "establishes the enduring framework the world needs to solve the climate crisis."[179]*

*On June 1, 2017, President Trump announced his intention to withdraw the United States from the Paris Agreement and ordered the federal government to "cease all implementation" of the agreement. President Trump said the Paris Agreement had imposed "draconian financial and economic burdens" on the United States and created "serious obstacles" to energy development.[180, 181] On Nov. 7, 2017, during the COP 23 UN climate talks in Bonn, Germany, Syria announced that it would sign the Paris agreement on climate change, leaving the United States as the only country that has rejected the global pact.[182] The United States officially left the Paris Climate Agreement on Nov. 4, 2020.[207]*

*On inauguration day (Jan. 20, 2021), President Joe Biden released a statement rejoining the Paris Climate Agreement. The United States officially rejoined the agreement 30 days later on Feb. 19,2021.[208, 209, 210]*

## 2.4. U.S. Debate over Climate Change Heats Up

*Al Gore's documentary An Inconvenient Truth premiered in 2006 and was seen by over 5 million people worldwide. The film warned that human-caused climate change was real, and that without immediate reductions in greenhouse gas emissions, catastrophic climate changes would severely disrupt human societies, leading to a possible collapse of industrial civilization.[145]*

*A IPCC assessment report stated that climate change was accelerating, which could lead to more war and conflict around the world, and the report called for urgent counter-measures to be implemented.[170] The IPCC and Al Gore jointly received the 2007 Noble Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change."[146] In response to the IPCC findings, a group of scientists formed the Nongovernmental International Panel on Climate Change (NIPCC) to compile a report challenging the science behind man-made climate change. Their Mar. 2, 2008 report, "Nature, Not Human Activity, Rules the Climate," was published by the Heartland Institute.[147]*

*Between 1998 and 2009, the United States allocated $99 billion to federal agencies for work related to climate change. During that period there was a big uptick in climate-related technology development while spending on climate science remained about the same.[151]*

*On Apr. 2, 2007, the US Supreme Court ruled (5-4) in Massachusetts v. EPA that greenhouse gases met the criteria to be considered pollutants under the Clean Air Act.[149] In response, the US EPA announced in 2009 that greenhouse gases "threaten public health" and are "the primary driver of climate change."[150] In its June 23, 2014 decision in Utility Air Regulatory Group v. EPA, the US Supreme Court upheld the EPA's authority to regulate greenhouse gas emissions from stationary sources such as power plants.[96]*

*On Sep. 21, 2014 the largest climate march to date took place in New York, NY, as over 400,000 people marched to demand that world governments take immediate action to reduce greenhouse gas emissions.[161] In Mar. 2019, as many as 1.4 million people worldwide participated in a school walk out to bring attention to climate change.[196] The student movement started by Swedish climate activist Greta Thunberg continued on Sep. 20, 2019 with an estimated four million demonstrators in at least 160 countries calling for action on climate change, an event that is thought to be the largest climate protest in history to that point.[197]*

*The Obama Administration enacted the strictest passenger vehicle fuel efficiency standards in US history as part of a plan to address climate change. The $CO_2$ standards set in 2012 required an annual 5% increase in fuel efficiency to reach 54.5 miles per gallon by 2025.[200] On Mar. 31, 2020, the Trump Administration lowered the requirement to a 1.5% increase each year towards a goal of 40 miles per gallon on average by 2026.[201] An analysis by Rhodium Group predicted the lowered standards would result in about 20% of the reduction in greenhouse gas emissions that were expected under the Obama-era standards.[202]*

## 2.5. How Will Climate Change Affect Us?

*According to NOAA's National Climatic Data Center, 2014 was the hottest year on record across the globe since 1880 when record keeping began.[94] The following five years were even warmer as 2016 set the record for hottest year ever and global average temperatures in 2019 were the second-hottest as of Mar. 2020.[198]*

*In 2019, $CO_2$ levels were 415.3 ppm (426.6 ppm in 2025), up from 315.7 ppm when measurements began in 1958.[194, 10] These $CO_2$ levels are reportedly higher than at any time in the last 650,000 years when levels fluctuated between 180 and 300 ppm.[102]*

*The United States makes up about 4% of the world's population but was responsible for nearly one-third of historical global greenhouse gas emissions.[103] In 2018, global emissions of human-produced $CO_2$ were about 37 billion tons.[199]*

*Predictions about how climate changes would affect civilization ranged from a Department of Defense report[154] detailing catastrophic weather events and a "significant drop in the human carrying capacity of the Earth's environment," to an Oregon Institute of Science and Health report detailing "an increasingly lush environment of plants and animals."[155]*

*The question of how climate change impacts extreme weather came to the forefront of public debate when wildfires raged across Australia for 240 days from 2019 through early 2020. A World Weather Attribution study found that climate change increased the likelihood of wildfires such as those in Australia by at least 30% since 1900.[203] William Reville, emeritus professor of biochemistry at University College Cork, noted that other factors also contributed to the fires, such as failing to clear undergrowth and leaves that fuel the fires, a shortage of skilled firefighters, population density, and arson.[204]*

## 2.6. IPCC Findings, National Climate Assessment, & Counterpoints

*On Sep. 27, 2013 the IPCC announced that it is now "extremely likely [95% confidence] that human influence has been the dominant cause of the observed warming since the mid-20th century."[156]*

*The Heartland Institute argued against human-caused global warming in its 2013 NIPCC report which said that global warming since 1860 is the result of natural "cycles driven by ocean-atmosphere oscillations, or by solar variations."[67]*

*The US Global Change Research Program released the 2014 National Climate Assessment on May 6, 2014. The report called climate change "a global public health problem," stated that climate change impacts are already "visible in every state," and concluded that human-induced "climate change is happening now."[16] The report was criticized by some members of Congress, including US Senator James Inhofe (R-OK), who stated that "we can all agree that natural variations in the climate are taking place, but man-made global warming still remains a theory."[157]*

*In Nov. 2018, Volume II of the 4th National Climate Assessment was published. It concluded, in part, that "rising temperatures, extreme heat, drought, wildfire on rangelands, and heavy downpours" are expected to increase and that "[w]ithout adaptation, climate change will continue to degrade infrastructure performance over the rest of the century, with the potential for cascading impacts that threaten our economy, national security, essential services, and health and well-being."[186] The Trump administration criticized the report, stating that "it's not based on facts… It's not data-driven. We'd like to see something that is more data-driven. It's based on modeling, which is extremely hard to do when you're talking about the climate."[187]*

## 2.7. U.S. Public Opinion

*A Jan. 22, 2019 report from the Yale Program on Climate Change Communication found that 73% of Americans think global warming is occurring, marking a ten percentage point increase over Mar. 2015; meanwhile, 14% of Americans deny climate change is happening. Six in ten surveyed (62%) believe that global warming is being caused by humans, while 23% attribute it to "natural changes in the environment."[192]*

**Author's comment:** See section 1 for the current public perception in the US.

*The group's 2018 report showed that 95% of liberal Democrats think global warming is happening and 84% think it is caused by humans. On the other end of the ideological spectrum, 40% of Republicans think global warming is happening and 26% think it is caused by humans.[193]*

*A 2017 Gallup poll found that 68% of Americans thought global warming was caused by human activity, up from 50% in 2010 and 61% in 2001, while 29% thought it was caused by natural causes, down from 46% in 2010 and 33% in 2001.[190]*

*A 2018 Pew Research Center poll found that 18% of Republicans in the Baby Boomer generation thought that "the earth is warming mostly due to human activity," compared to 36% of millennial Republicans and 75% of all Democrats.[188] A July/Aug. 2019 Washington Post-Kaiser Family Foundation survey found that 86% of teenagers believe human activity is causing climate change, compared to 79% of adults.[195]*

# 3. Human Caused Climate Change, Pro Arguments

***Pro 1: Overwhelming scientific consensus finds human activity primarily responsible for climate change.***

*According to many peer-reviewed studies, over 97% of climate scientists agree that human activity is extremely likely to be the cause of global climate change.[7] Most scientific organizations also support this view, including the American Medical Association and an international coalition of science academies.[7]*

*A prominent review of 11,944 peer-reviewed studies on climate change found that only 78 studies (0.7%) explicitly rejected the idea of anthropogenic (resulting from human activity) global warming.[1] A separate review of 13,950 peer-reviewed studies on climate change found only 24 that rejected human-caused global warming.[5] An examination of scientific papers that didn't agree that humans cause climate change found serious flaws and bias in their research.[206]*

***Pro 2: Rising levels of human-produced gases released into the atmosphere create a greenhouse effect that traps heat and causes global warming***

*Gases released into the atmosphere trap heat and cause the planet to warm through a process called the greenhouse effect.[8] When we burn fossil fuels to heat our homes, drive our cars, and run factories, we're releasing emissions that cause the planet to warm.[9]*

*Methane, which is increasing in the atmosphere due to agriculture and fossil fuel production, traps 84 times as much heat as $CO_2$ for the first 20 years it is in the atmosphere,[11] and is responsible for about one-fifth of global warming since 1750.[12] Nitrous oxide, primarily released through agricultural practices, traps 300 times as much heat as $CO_2$.[13] Over the 20th century, as the concentrations of $CO_2$, $CH_4$ (methane), and $NO_2$ (nitrous oxide) increased in the atmosphere due to human activity,[13, 14] the earth warmed by approximately 1.4°F.[99]*

**Author's comment:** Nitrous oxide's composition in the atmosphere is pretty tiny (270 ppb (parts per billion), and it's not growing very rapidly (about 1 ppb per year), although it has a long half-life in the atmosphere (120 years).

Methane has a half-life of about 10 years in the atmosphere. More than 90% of methane is naturally broken down, or oxidized, into $CO_2$ and water vapor in the atmosphere.

$CO_2$ is a greenhouse gas, and although it is much less potent than methane, it is much longer-lived. Some freshly emitted $CO_2$ is quickly taken up by the ocean, plants, and soil within a few years. The second part goes on a scale of centuries to millennia, but that only gets 80% of it. The last of the carbon dioxide that enters the atmosphere takes tens of thousands of years to leave.

Water (vapor) is a natural component of the atmosphere and also is a greenhouse gas, but there are many sources and sinks for water vapor. At worst, the water vapor from methane degradation might increase the background level of water vapor slightly.

Earth will likely have warming of 1.5°C or greater in 2025 vs. preindustrial times. It might drop below this level briefly in future years, but the long term average is likely to stay above this level until we reduce greenhouse gasses significantly and permanently in a future year.

***Pro 3: The rise in atmospheric $CO_2$ over the last century was clearly caused by human activity, as it occurred at a rate much faster than natural climate changes could produce.***

*Over the past 650,000 years, atmospheric $CO_2$ levels did not rise above 300 ppm until the mid-20th century.[100] Atmospheric levels of $CO_2$ have risen from about 317 ppm in 1958 to 415 ppm in 2019,[10, 194] and in January 2025 the atmospheric $CO_2$ levels were 426 ppm. According to the Scripps Institution of Oceanology, the "extreme speed at which carbon dioxide concentrations are increasing is unprecedented. An increase of 10 parts per million might have needed 1,000 years or more to come to pass during ancient climate change events."[17] Some climate models predict that by the end of the 21st century an additional 5°F-10°F of warming will occur.[16]*

***Pro 4: The specific type of $CO_2$ that is increasing in earth's atmosphere can be directly connected to human activity.***

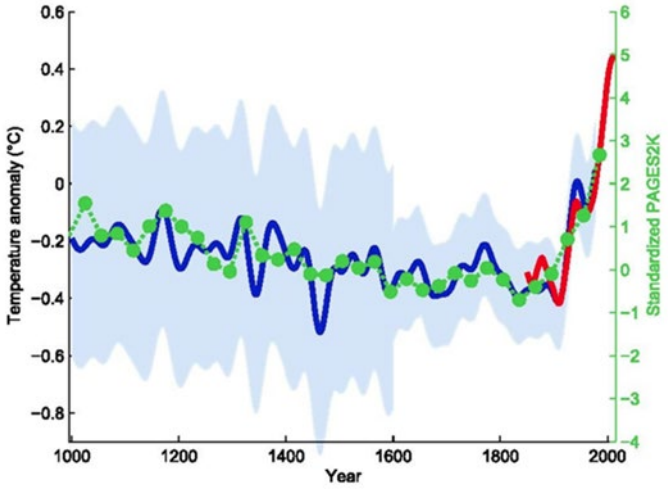
*We can tell that $CO_2$ produced by humans burning fossil fuels such as oil and coal[18] is different than naturally occurring $CO_2$ by looking at the specific isotopic ratio.[101] According to the Intergovernmental Panel on Climate Change (IPCC), 20th century measurements of $CO_2$ isotope ratios in the atmosphere confirm that rising $CO_2$ levels are the result of human activity as opposed to gas coming off the oceans, volcanic activity, or other natural causes.[102]*

*The US Environmental Protection Agency says that "Human activities are responsible for almost all of the increase in greenhouse gases in the atmosphere over the last 150 yr."[19]*

***Pro 5: Average temperatures on earth have increased at a rate far faster than can be explained by natural climate changes.***

*Average surface temperatures on earth have risen more than 2°F over the past 100 years.[205] According to NASA, "The current warming trend is of particular significance because most of it is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20th century and proceeding at a rate that is unprecedented over… millennia."[24]*

*A 2008 study comparing data from tree rings, ice cores, and corals over the past millennium created the famous "hockey stick" graph showing a steady trend in the earth's temperature over the last 1,700 years followed by a steep jump in the previous decade (forming a shape like a hockey stick).[23] Berkeley scientists found that the average temperature of the earth's land increased 2.5°F over 250 years (1750-2000), 1.5°F of which "appears likely" to be attributable to humans over the past 50 years.[21] See chart on the next page.[4]*




The original northern hemisphere hockey-stick graph of Mann, Bradley & Hughes 1999, smoothed curve shown in blue with its uncertainty range in light blue, overlaid with green dots showing the 30-year global average of the PAGES 2k Consortium 2013 reconstruction. The red curve shows measured global mean temperature.[5]

### *Pro 6: Natural changes in the sun's activity cannot explain 20th century warming.*

*The amount of solar energy received by the earth goes up and down in cycles, but overall, there is no net change since the 1950s. There has, however, been a big increase in global temperatures that is too large to attribute to the sun. For this reason, NASA and other scientists say the sun is not responsible for global warming.[28] The sun has had only a minor effect on the Northern Hemisphere climate over the past 1,000 years, and global warming from human-produced greenhouse gases has been the primary cause of climate change since 1900.[26] A study found that solar activity could not have contributed to more than 10% of the observed global warming over the 20th century.[27]*

### *Pro 7: Global warming caused by human-produced greenhouse gases is causing the Arctic ice cap to melt at an increasing rate.*

*From 1953–2006, Arctic-sea-ice declined 7.8% per decade. Between 1979 and 2006, the decline was 9.1% each decade.[105] By 2019, Arctic-sea-ice was being lost at a rate of 12.9% per decade.[163] As the Arctic ice cover continues to decrease, the amount of the sun's heat reflected by the ice back into space also decreases. This positive-feedback loop amplifies global warming at a rate even faster than previous climate models had predicted.[30] Some studies predicted the Arctic could become nearly ice free sometime between 2020-2060.[164]*

### *Pro 8: Sea levels are rising at an unprecedented rate due to human activities.*

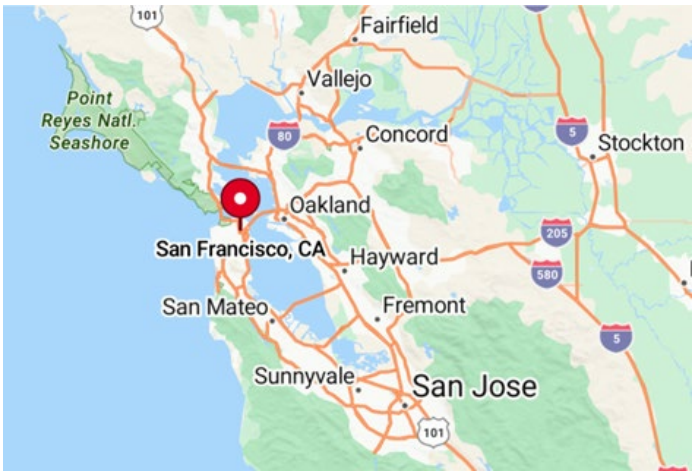
*Sea levels rise due to thermal expansion of warming ocean waters and melt water from receding glaciers and the polar (Antarctic and Greenland) ice caps.[165] According to the IPCC, there has been a "substantial" human contribution to the global mean sea-level rise since the 1970s.[29] As much as 87% of the rise in sea levels since 1970 resulted from human activities such as burning fossil fuels.[35]*

[5] Affiliations: Dr. Michael Mann, Penn State; Dr. Raymond S. Bradley, the U-Mass, Amherst; Dr. Malcolm Hughes, University of Arizona.

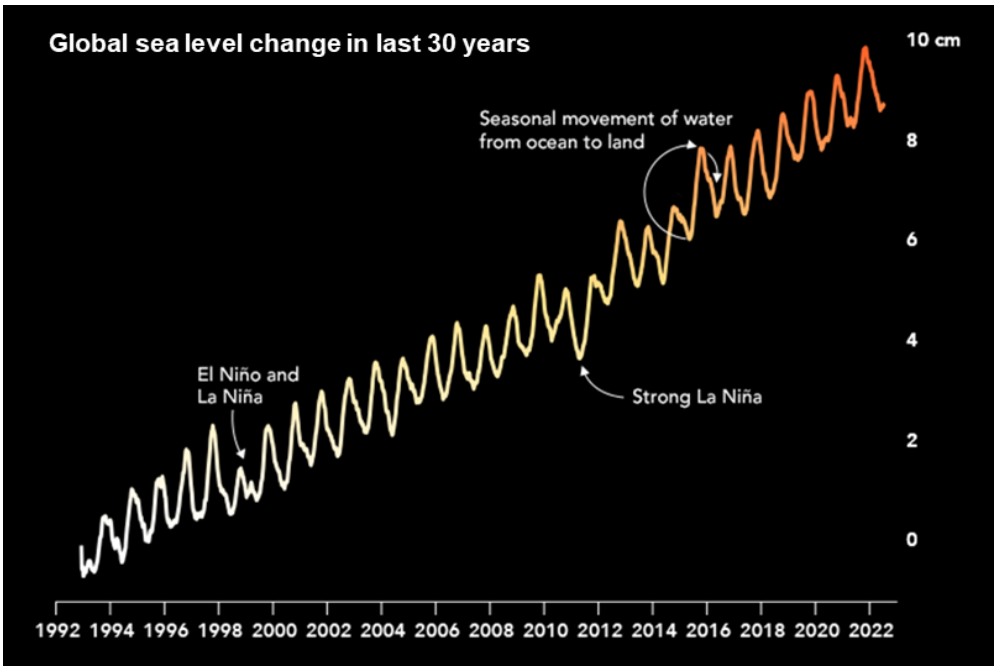
*A study found that "significant acceleration" of sea-level rise occurred from 1870 to 2004.[106] Between 1961 and 2003, global sea levels rose 8 inches; a 2019 UN report said they could rise by 3 feet in the next 80 years, displacing hundreds of millions of people.[102, 20] A study published in the Proceedings of the National Academy of Sciences concluded that the rate of sea level rise over the past century is unprecedented over the last 6,000 years.[32, 33]*

**Author's comment:** See the chart below.[6]

Your author does not have any risk associated with sea-level rise, but my home area does. My Livermore Valley floor is at roughly 400 ft. above sea level. However, the San Francisco Bay Area (SF Bay Area, map right) region has a major problem. Note that 10 cm in chart below is about 4 inches.




*The shoreline of the San Francisco Bay comprises approximately one third of the total California coastline. The wonder and beauty of our Bayshore and Pacific Coast waterfronts are major contributory factors to making this a vibrant and extraordinary city and region in which to live.[7]*




[6] https://earthobservatory.nasa.gov/images/150192/tracking-30-years-of-sea-level-rise

[7] https://sfplanning.s3.amazonaws.com/default/files/plans-and-programs/planning-for-the-city/sea-level-rise/160309_SLRAP_Executive_Summary_EDreduced.pdf

*Sea level rise may be a slow-moving threat to our city but it demands our action now. Climate change is accelerating the rate at which oceans are rising and our lower-lying shoreline areas are increasingly exposed to flood waters. Over the next several decades, these hazards will increase in frequency and extent. In March of 2015, I convened an interagency task force of twelve City departments to work together to develop this thoughtful and collaborative Sea Level Rise Action Plan for San Francisco.*[8]

*- San Francisco Mayor Ed Lee, March 2016*

***Pro 9: Ocean acidity levels are increasing at an unprecedented rate that can only be explained by human activity.***

*As excess human-produced $CO_2$ in the atmosphere is absorbed by the oceans, the acidity level of the water increases. Acidity levels in the oceans are 25-30% higher than prior to human fossil fuel use.*[107] *The US Government Accountability Office (GAO) said oceans have absorbed about 30% of the $CO_2$ emitted by humans over the past 200 years, and ocean acidity could rise approximately 100-200 percent above preindustrial levels by 2100.*[36]

*The World Meteorological Organization said the current acceleration in the rate of ocean acidification "appears unprecedented" over the last 300 million years.*[37] *High-ocean-acidity-levels threaten marine species,*[16] *and slows the growth of coral reefs.*[38] *The Convention on Biological Diversity said "it is now nearly inevitable" that within 50-100 years continued human-produced $CO_2$ emissions will increase ocean acidity to levels that harm marine organisms and ecosystems.*[39]

***Pro 10: Ocean temperatures are rising at an unprecedented rate due to anthropogenic global warming.***

*Peter Gleckler, PhD, a climate scientist at Lawrence Livermore National Laboratory, said, "The bottom line is that… most of the observed global ocean warming over the past 50 years is attributable to human activities."*[42] *The IPCC stated in a report that due to human-caused global warming, it is "virtually certain" (99-100% probability) that the upper ocean warmed between 1971 and 2010.*[29] *The oceans absorb more than 90% of the heat generated by human-caused global warming.*[41] *Since 1970, the upper ocean (above 700 meters) has been warming 24-55% faster than previous studies had predicted.*[41]

*Warmer ocean waters can harm coral reefs and impact many species including krill, which are vital to the marine food chain and which reproduce significantly less in warmer water.*[166] *Warming oceans also contribute to sea level rise due to thermal expansion, and can add to the intensity of storm systems.*[167]

***Pro 11: Glaciers are melting at unprecedented rates due to global warming, causing additional climate changes.***

*About a quarter of the globe's glacial loss from 1851-2010, and approximately two thirds of glacial loss between 1991-2010, is attributable directly to global warming caused by human-produced greenhouse gases.*[45] *According to the National Snow and Ice Data Center, global warming from human-produced greenhouse gases is a primary cause of the "unprecedented" retreat of glaciers around the world since the early 20th century.*[44]

[8] https://sfpublicworks.org/about/san-francisco-sea-level-rise-action-plan

*Since 1980, glaciers worldwide have lost nearly 40 feet (12 meters) in average thickness.[110] According to an IPCC report, "glaciers have continued to shrink almost worldwide" over the prior two decades, and there is "high confidence" (about an 8 out of 10 chance) that Northern-Hemisphere spring snow continues to decrease.[29] If the glaciers forming the Greenland ice sheet were to melt entirely, global sea levels could increase by up to 20 feet.[168]*

***Pro 12: Human-caused global warming is changing weather systems and making heat waves and droughts more intense and more frequent.***

*A National Climate Assessment report said human-caused climate changes, such as increased heat waves and drought, "are visible in every state."[16] The American Meteorological Society found that anthropogenic climate change "greatly increased" (up to 10 times) the risk for extreme heat waves.[46] Globally, 75% of extremely hot days are attributable to warming caused by human activity.[174] A World Weather Attribution study found that anthropogenic climate change increased the likelihood of wildfires such as the ones that raged across Australia in 2019-2020 by at least 30% since 1900.[203]*

**Author's comment:** and in Southern California this year (2025).

***Pro 13: Dramatic changes in precipitation, such as heavier storms and less snow, are another sign that humans are causing global climate change.***

*As human-produced greenhouse gases heat the planet, increased humidity (water vapor in the atmosphere) results. Water vapor is itself a greenhouse gas.[112] In a process known as a positive feedback loop, more warming causes more humidity which causes even more warming.[113] Higher humidity levels also cause changes in precipitation. According to a report published in the Proceedings of the National Academy of Sciences, the recorded changes in precipitation over land and oceans "are unlikely to arise purely due to natural climate variability."[48]*

*According to researchers at the Scripps Institution of Oceanography, up to 60% of the changes in river flow, winter air temperature, and snow pack in the western United States (1950-1999) were human-induced.[111] Since 1991, heavy precipitation events have been 30% above the 1901-1960 average in the Northeast, Midwest, and upper Great Plains regions.[16] A study found that global warming caused by human actions has increased extreme precipitation events by 18% across the globe, and that if temperatures continue to rise an increase of 40% can be expected.[174]*

***Pro 14: Permafrost is melting at unprecedented rates due to global warming, causing further climate changes.***

*According to the IPCC, there is "high confidence" (about an 8 out of 10 chance) that anthropogenic global warming is causing permafrost, a subsurface layer of frozen soil, to melt in high-latitude regions and in high-elevation regions.[49] As permafrost melts it releases methane, a greenhouse gas that absorbs 84 times more heat than $CO_2$ for the first 20 years it is in the atmosphere, creating even more global warming in a positive feedback loop.[50, 51]*

*By the end of the 21st century, warming temperatures in the Arctic will cause a 30%-70% decline in permafrost.[52] As human-caused global warming continues, Arctic air temperatures are expected to increase at twice the global rate, increasing the rate of permafrost melt, changing the local hydrology, and impacting critical habitat for native species and migratory birds.[53] According to the 2014 National Climate Assessment, some climate models suggest that near-surface permafrost will be "lost entirely" from large parts of Alaska by the end of the 21st century.[16]*

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